Overview Run-5 Cu-Cu

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overall results

- **delivered 15 nb^{-1}** in the **100 GeV/u** run (**HE**), more than twice the goal of 7 nb^{-1}
- **exceeded maximum luminosity projections**
- **set&ramp-up time** with beam **2 ½ weeks** (4 weeks planned)
- 2 experiments reached the **HE physics goal in 8 weeks (**the other 2 a significant fraction)
- successful **2 weeks** at **31.2 Gev/u (LE),** set-up **2 days**
- successful **1 day run** at **injection 11 GeV/u (IE)**

*despite initial hurdles: **budget** vagaries, D6 and bus-2-bus short →**warm-up and repair**, **aperture** obstruction….*

outline

- **overall machine performance**

  chronology, injectors, integrated lumi, lumi/week, uptime

- **performance limitations**

  on bunch intensity, number of bunches

- **run-5 new developments, system highlights**

  most relevant to operations

Talk tomorrow: *comparison HE vs. LE run, and discussion of machine performance vs. reliability*

chronology

June 7-9	Retreat
Aug 16	choice of ion
Sep 7	start **cool-down to 80K** (on hold – budget uncertainties)
Nov 15	start **injectors set-up** for Cu
Nov 18	start **cool-down to 4 K**
Nov 22	beam circulating at injection in blue (54 minutes!)
Dec 1st	**shorts** discovered in yellow (10: D6, 12: Q3 splice)
Dec 4-21	warm-up, repair, cool-down
Dec 23-25	re-start beam ops, blue ramp with 95% transmission
Tue Dec 28	**set-up starts both beams** → yellow obstruction
Dec 31	both rings at store
Tue Jan 4	**ramp-up starts** – **collisions overnight**
Tue Jan 11	**HE physics starts** – with 28x28 4.5e9
Mar 7-22	**LE set-up** (2.5 days) and **physics run**
March 23	**injection run**

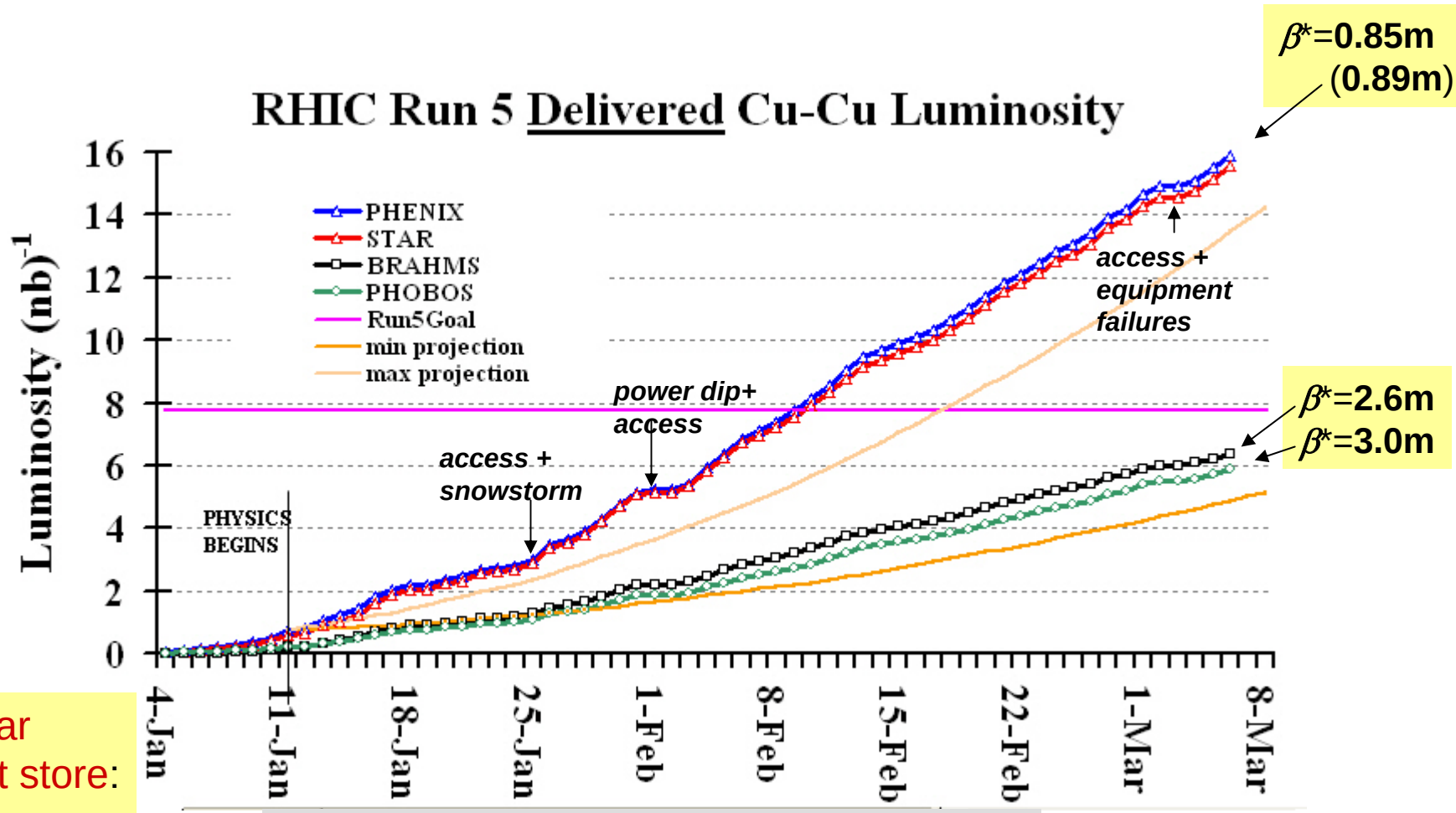
2 weeks

Injectors - highlights

- **set-up** injector complex for Cu: ~ **1 week**
- **steady** delivery of required **4.5 - 5 x 10^9** Cu ions/bunch
- up to **7 x10^9** ions/bunch delivered for experiments
- transverse emittance **9-11 π mm mrad**
- longitudinal emittance **0.4 eV sec/u**

(→ talks Leif, Kip, Haixin)

Integrated luminosity 100 GeV/u



calendar time at store: **52%**

Cu-cu cross section measured at 2.6 barn

projections vs. performance

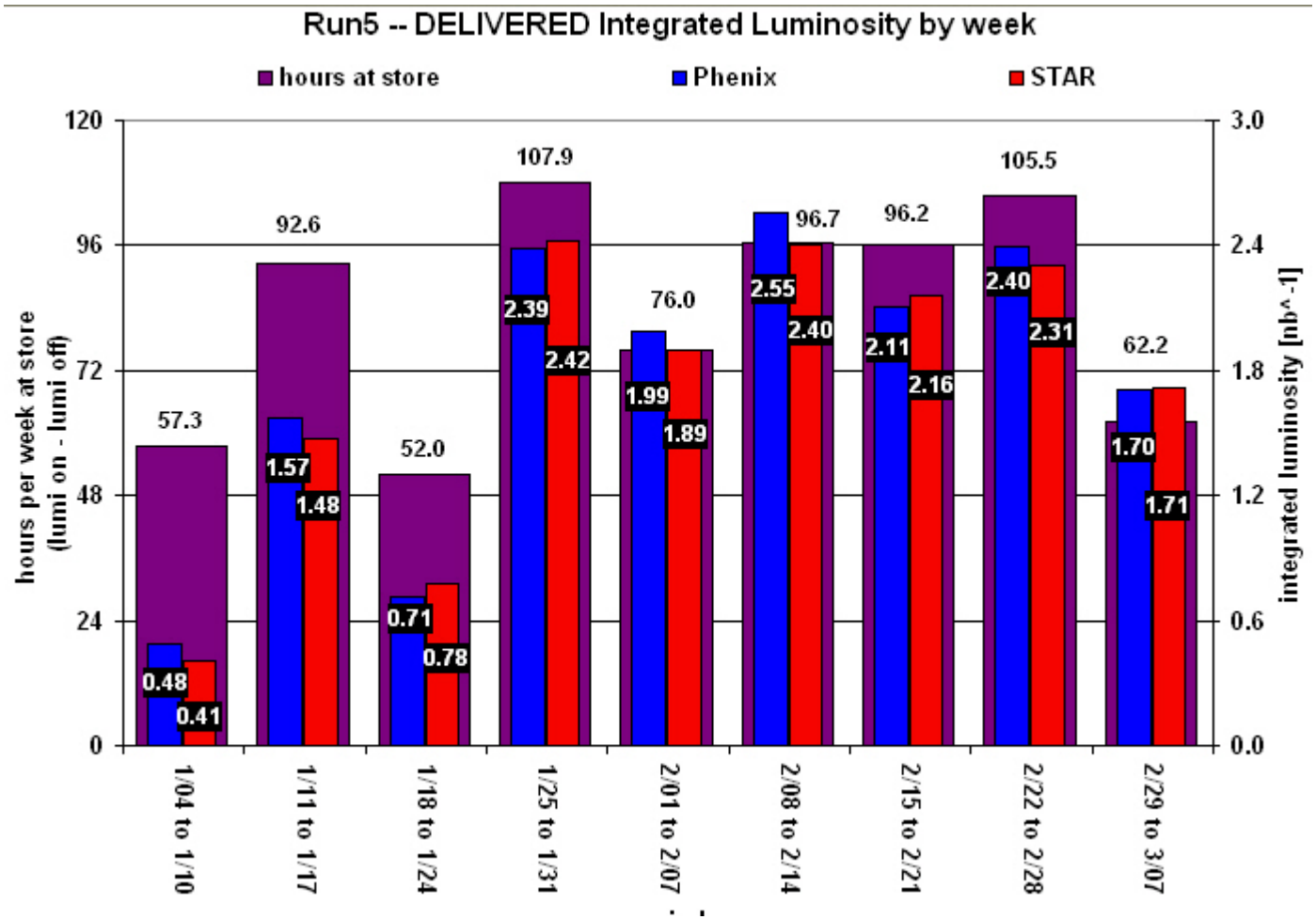
Factors for exceeding projections (HE):

- β^* squeeze **1m** (*measured 1.1m*) → **0.85** (*0.89*)
- optimization intensity, #bunches
- luminosity ramp-up faster than the model used in the projections
- accurate prediction of lumi slope

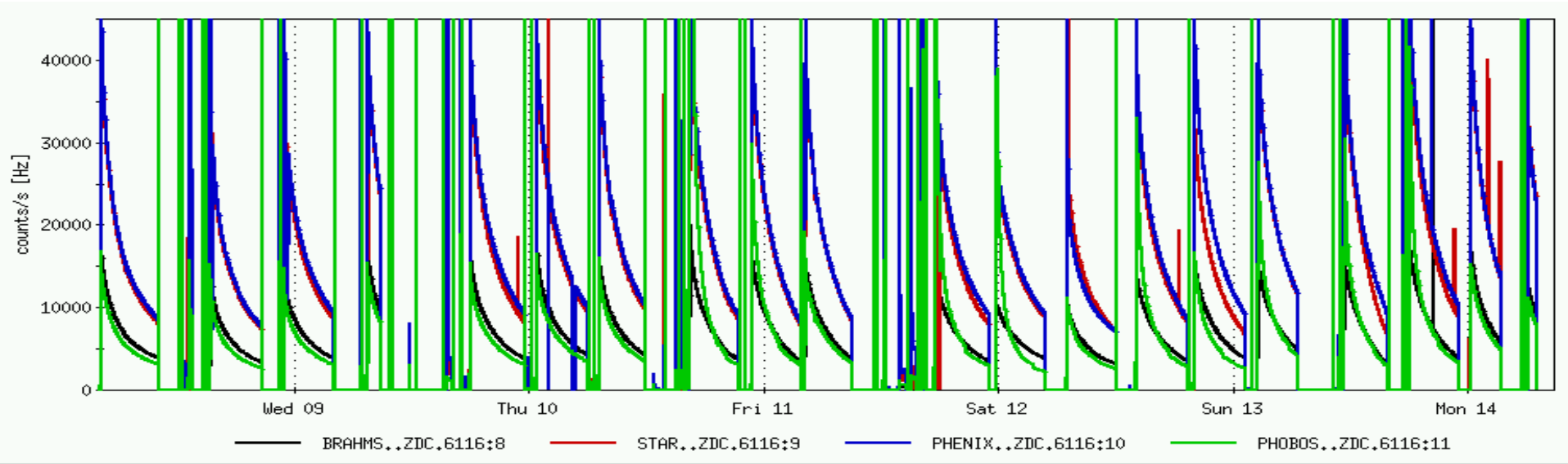
Big (luminosity) Dippers: (visible dents in lumi plot)

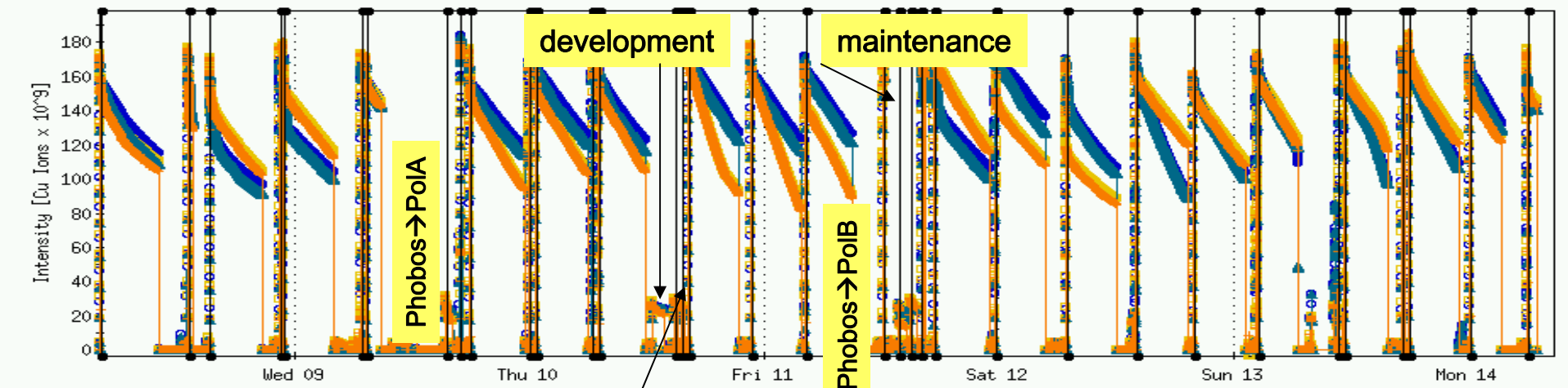
- access + snowstorm
- power dip + access
- access + series of ensuing equipment failures

Luminosity / week



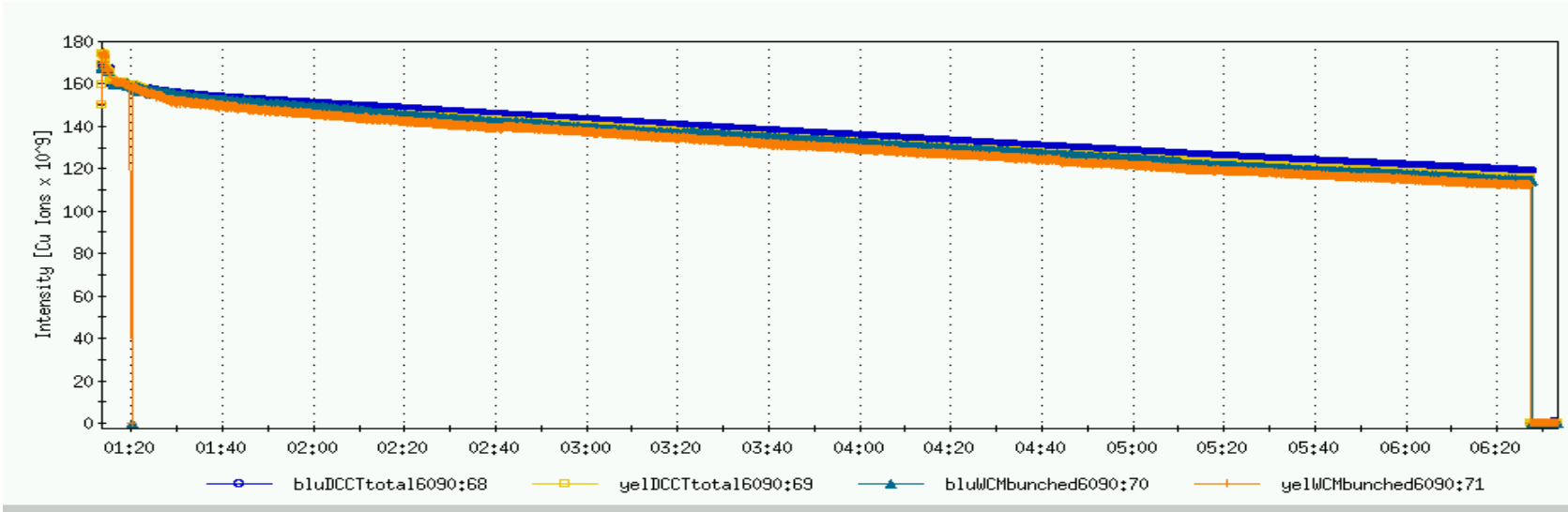
Rates, intensities – week 5

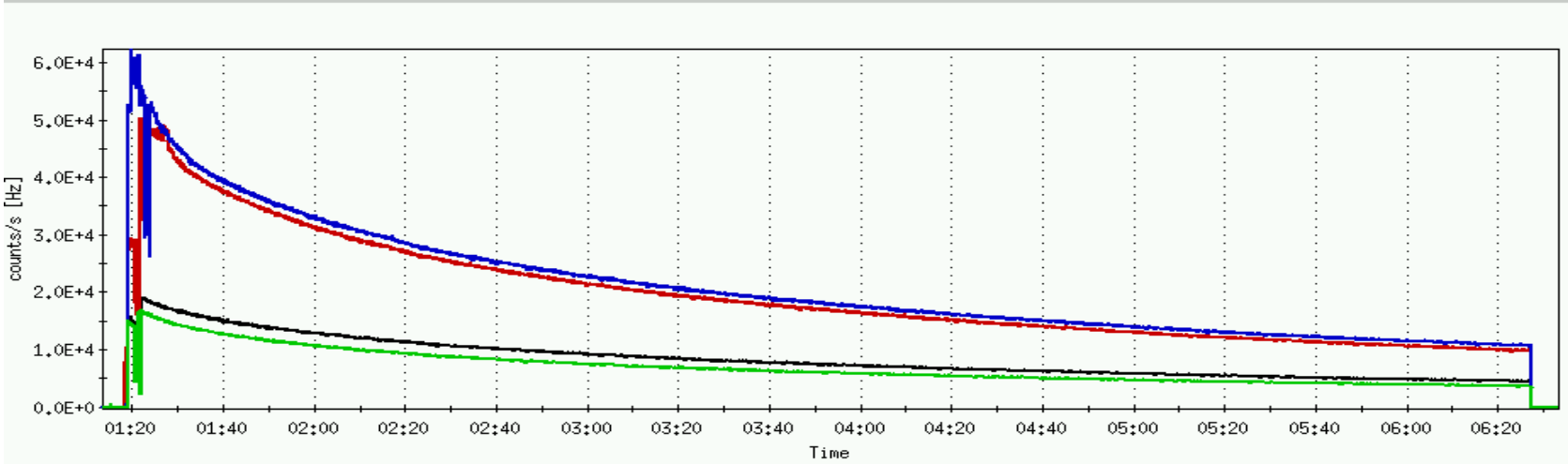




Phobos PR

Store 6090

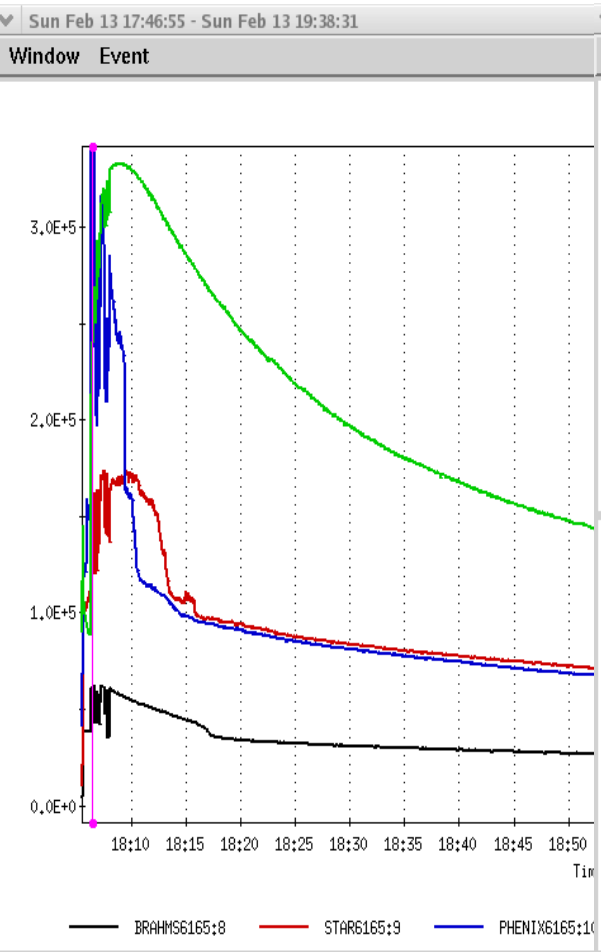

Intensity [Cu Ions x 10^9]
180
160
140
120
100
80
60
40
20
0
01:20
01:40
02:00
02:20
02:40
03:00
03:20
03:40
04:00
04:20
04:40
05:00
05:20
05:40
06:00
06:20
bluDCCTtotal6090:68
yelDCCTtotal6090:69
bluWCMbunched6090:70
yelWCMbunched6090:71

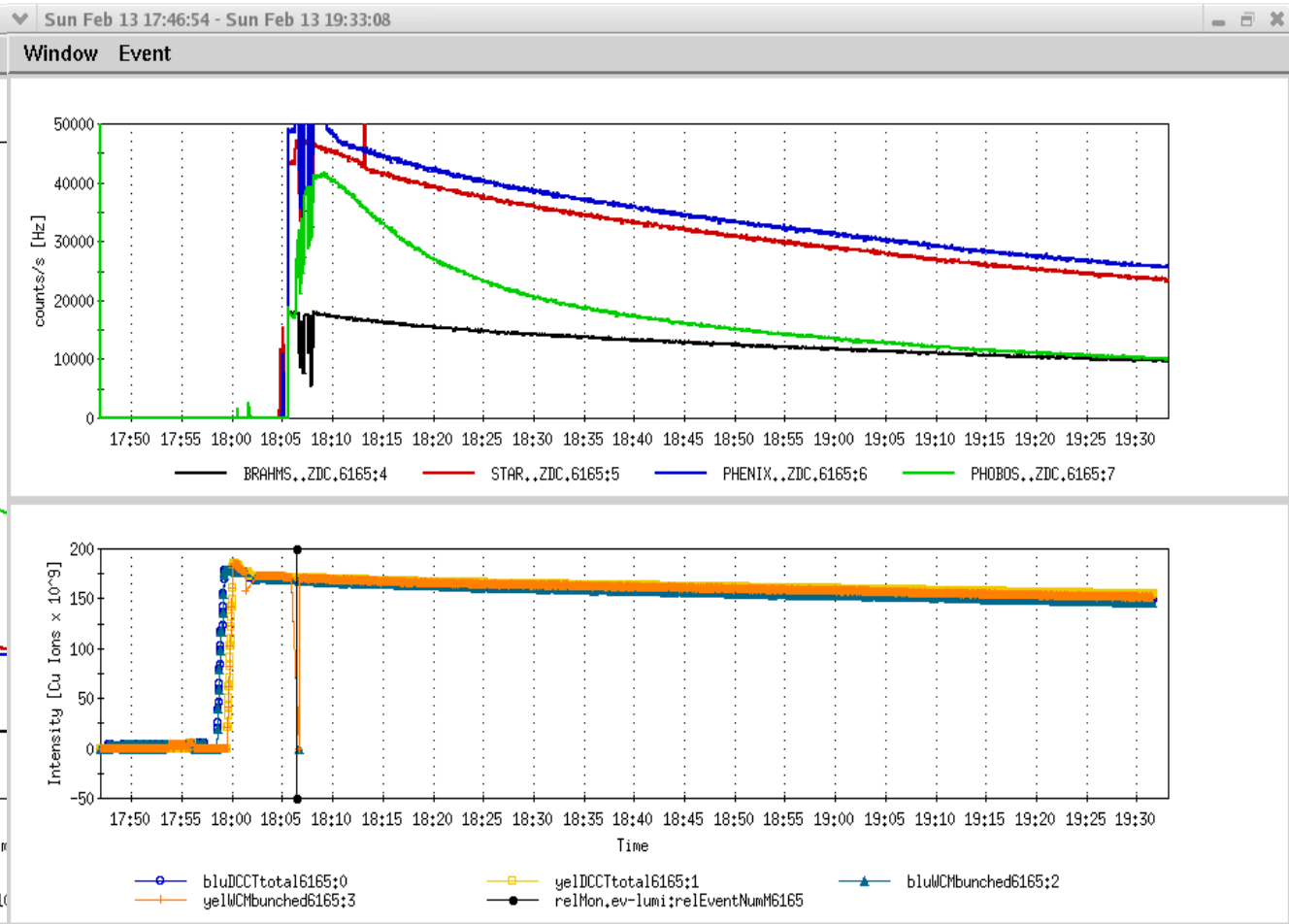

counts/s [Hz]
6.0E+4
5.0E+4
4.0E+4
3.0E+4
2.0E+4
1.0E+4
0.0E+0
01:20
01:40
02:00
02:20
02:40
03:00
03:20
03:40
04:00
04:20
04:40
05:00
05:20
05:40
06:00
06:20
Time

Store 6165 37x(4.8-5.0)

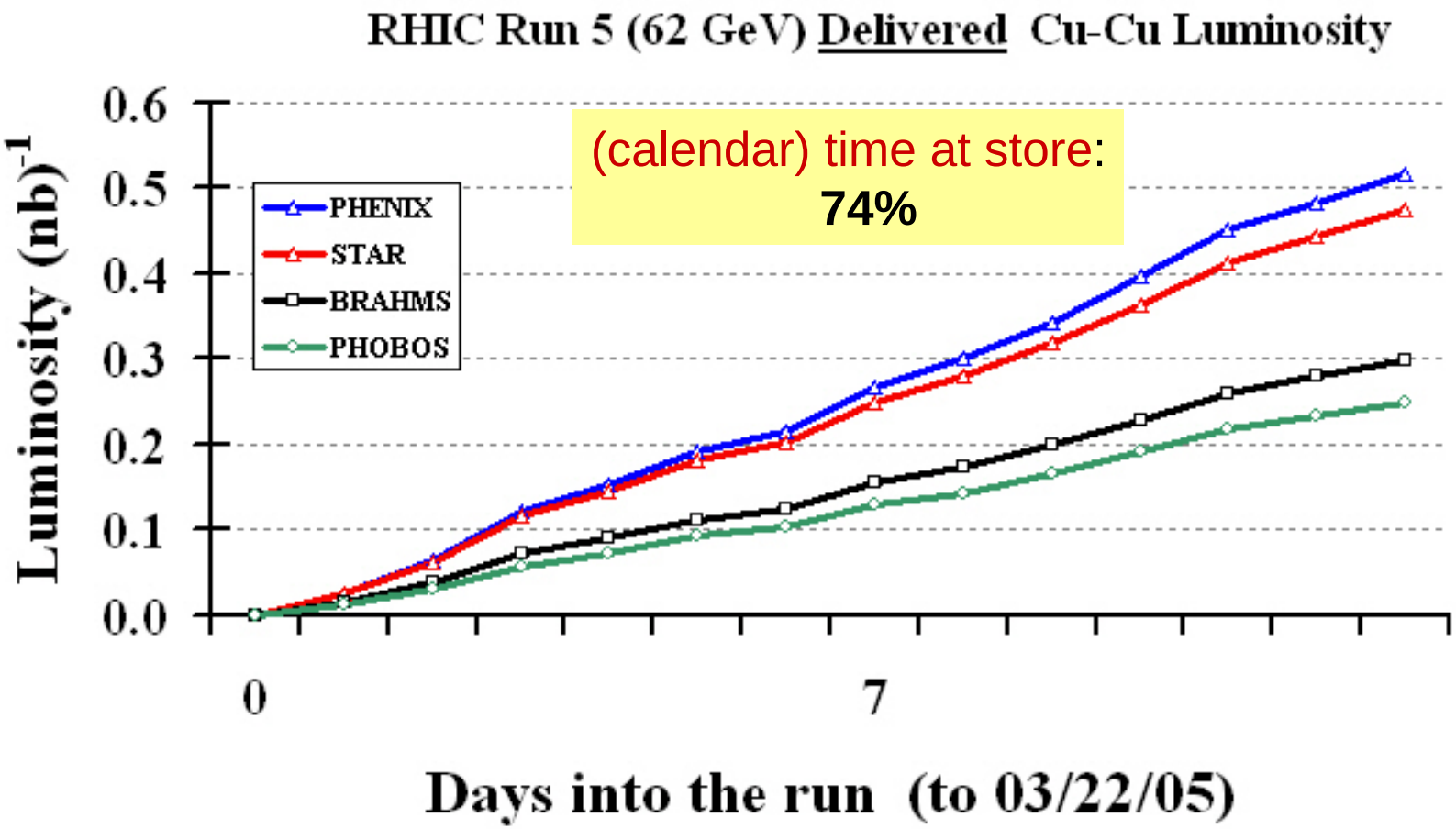
No lifetime problems – Phenix initial ~50K

12 minutes ev-lumi to collimation done





Integrated lumi 31.2 GeV run



Performance limitations (HE)

Bunch intensity (limit ~5x10^9)

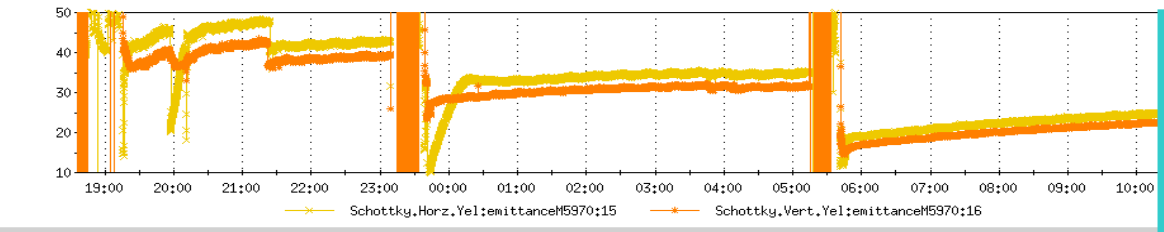
- fast transverse instabilities near transition
- yellow beam lifetime after re-bucketing
- beam-beam (at store)
- IBS

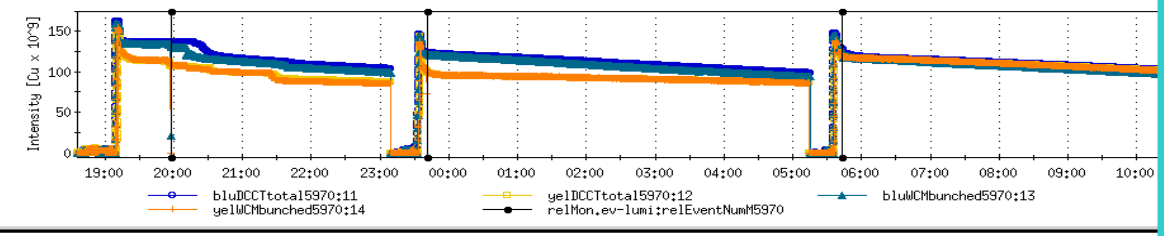
Number of bunches

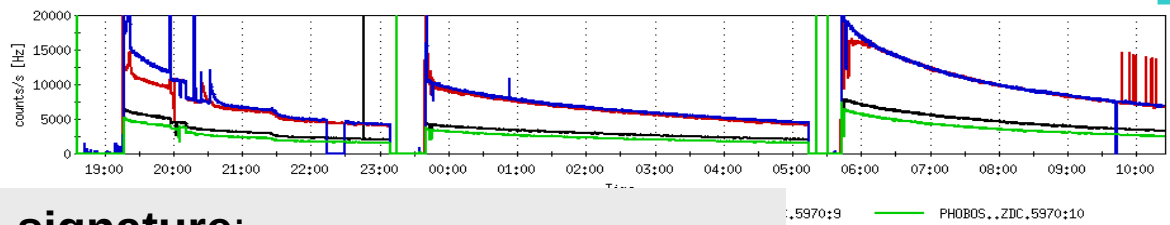
- pressure rise at Phobos (limit: 43x43)
- transition pressure rise at IR4 (limit: 45x45)
- long range beam-beam interactions on the ramp

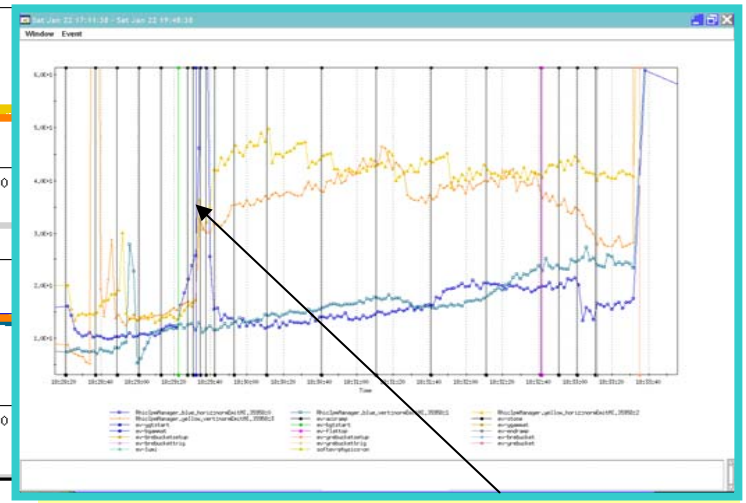
  (limit < 28x28 before improvements)

Fast instability around transition









emittance blow-up ~0.5 sec after transition

signature:

- coherence (0.1-0.8 sec > γt)
- fast loss on DCCT
- 50% emittance blow-up
- no dependence #bunches
- no clear bunch intensity threshold

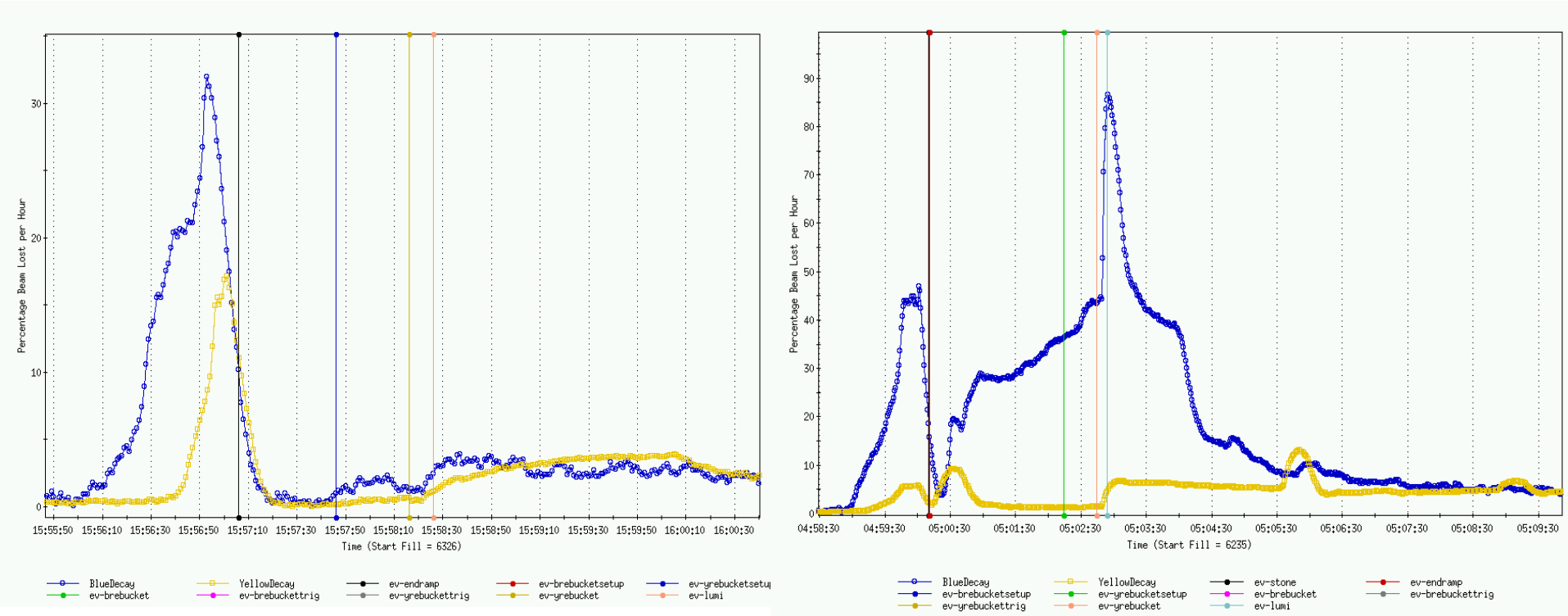
effects:

- bad lifetime
- low rates
- high backgrounds

cures:

- octupoles (not enough)
- zero-crossing of chromaticity moved before γt

Beam lifetime after re-bucketing



beam decay→ tuning → delay start of physics

- need to keep **chromaticity very close to zero** at and after re-bucketing
- exacerbated by **close orbit shifts** with periodicity of 24 h *(→Vadim's talk)*

Beam-beam (store) & IBS

beam-beam at store

→ emittance growth→lumi lifetime

- tolerable nevertheless with Cu and 4 interactions

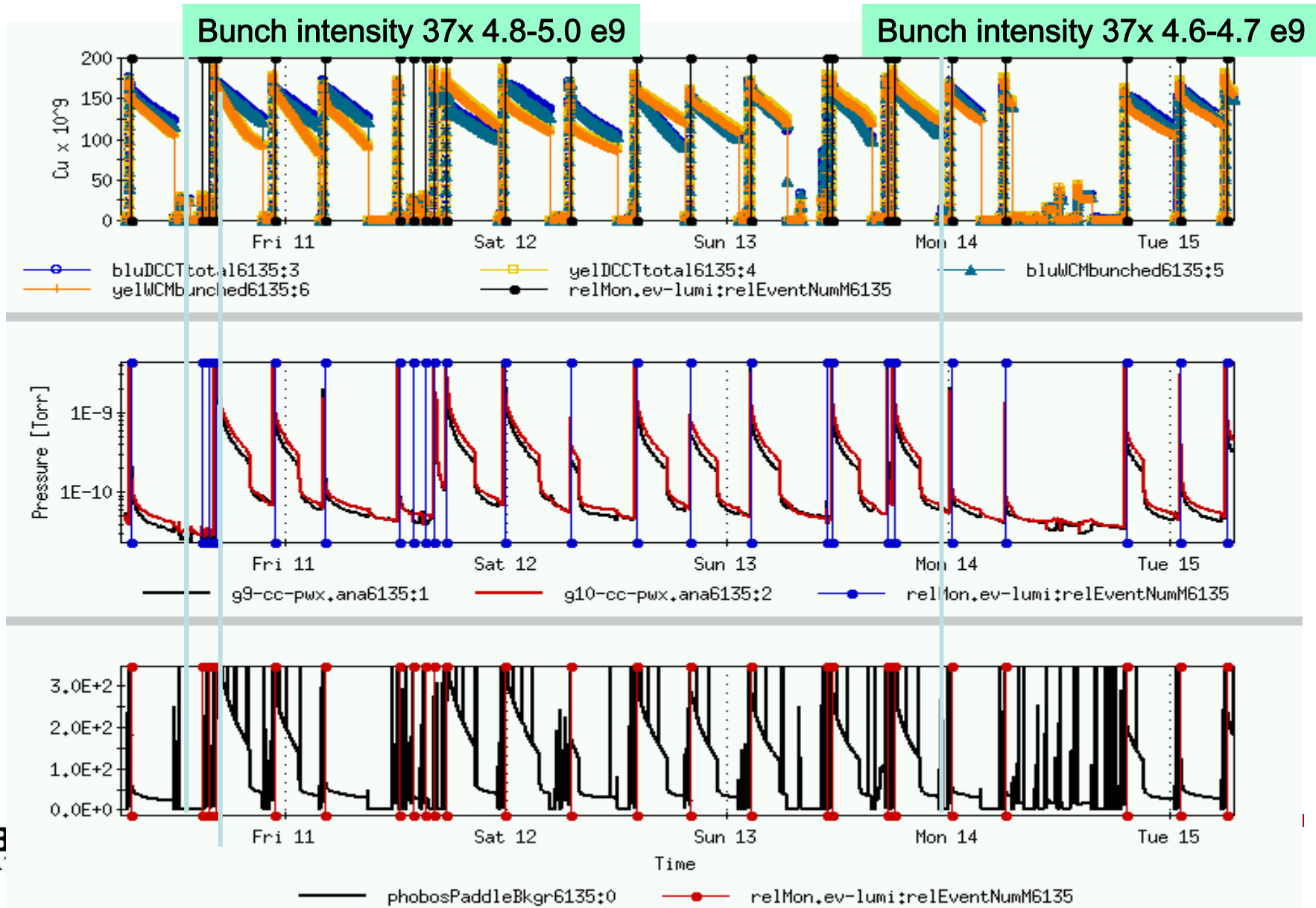
(Δ intensity loss of bunches with 3 and 4 interactions marginal)

- cure: **working point** control (move to 0.73 not necessary)

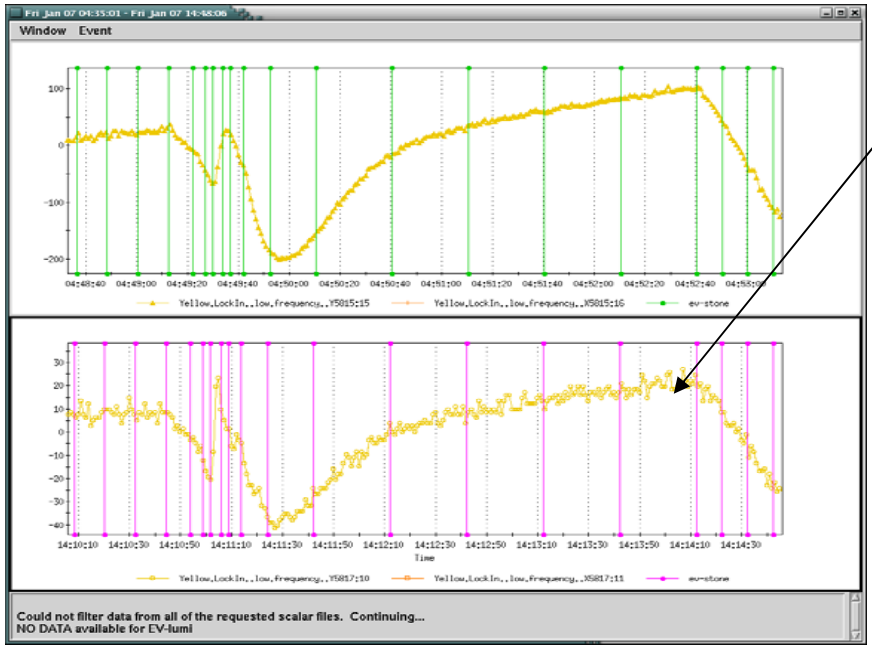
IBS

- From pre-run simulations (Fedotov, Wang), IBS less than for Au but significant
- measured and compared during AP experiments
- **operations**: **common cavities**, **continuous gap cleaning**

Phobos PR and background

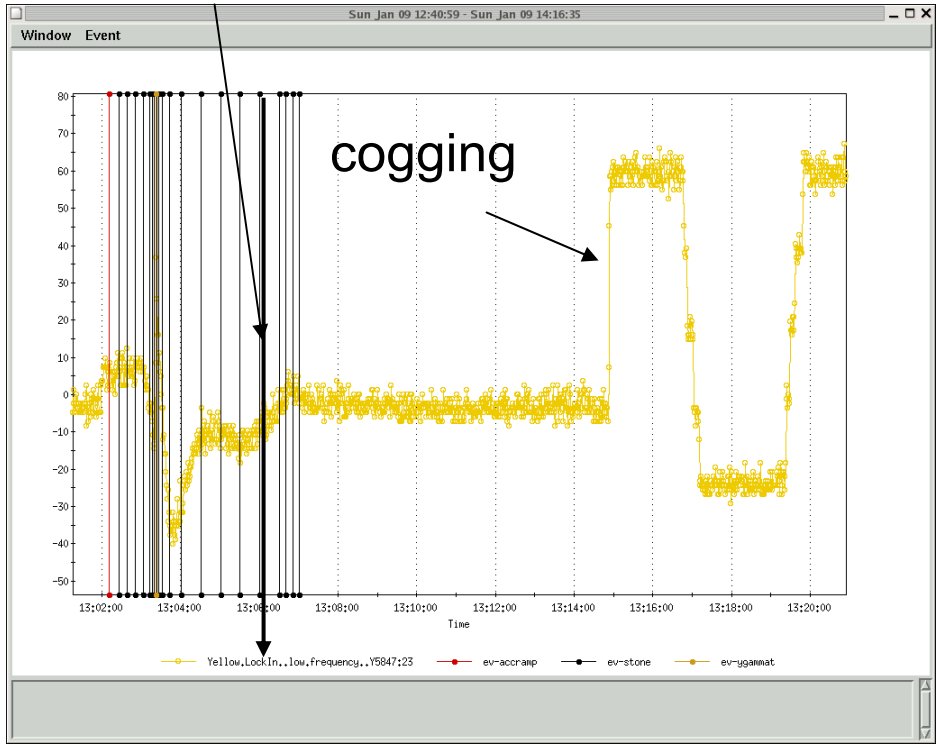


Long range beam-beam (ramp)



increased ring2ring synchro loop gain

RF dipole



significant losses around transition and the beta squeeze
had to be fixed to allow the initial physics store with 28 bunches
Cure: increase of R-2-R synchro-loop
RF dipole
(vertical separation bumps)

Run-5: new developments - 1

- **β^*-squeeze to 0.85m** (Pilat, Malitsky, Ptitsyn, Wittmer)

  tested run-5 in AP-ex

  operational run-5, measured β^*=0.89m

  took down separation bump during squeeze

  'usual' initial fight with coupling on the squeeze

  sextupole IR corrections

  *online matching capability (→ **talk Nikolay**)*

- **coupling corrections on the ramp** (Luo)

  tested during Run-4 & Run-5 AP-ex

  coupling vector amplitude modulation and phase rotation

  *operational in Run-5 → success (→**talk Yun**)*

Run-5 new developments - 2

- **Stochastic cooling tests** (Brennan, Blaskiewicz)

  (→talk Mike)

- **Injection into RHIC**

  automated injection set-up (Fisher)

  low-intensity interlock (Michnoff)

  auto AGS extraction field correction (Morris, Marneris…)

- **Configuration control, analysis tools**

  configuration control web page (Marr)

  FDAView (Todd)

  (→talks Greg, John)

Run-5 new developments - 3

instrumentation

- BPMS: electronics *(→ talk Rob),* BBA
- IPM re-work
- HF Schottky development (emittance)

  (→ talk Vladimir)

vacuum system

200+ m of NEG pipes → validation *(→talk Haixin)*

power supplies

PS swaps from 60 to 6 in 2 years *(→talk Don)*

RF *(→talk Mike)*

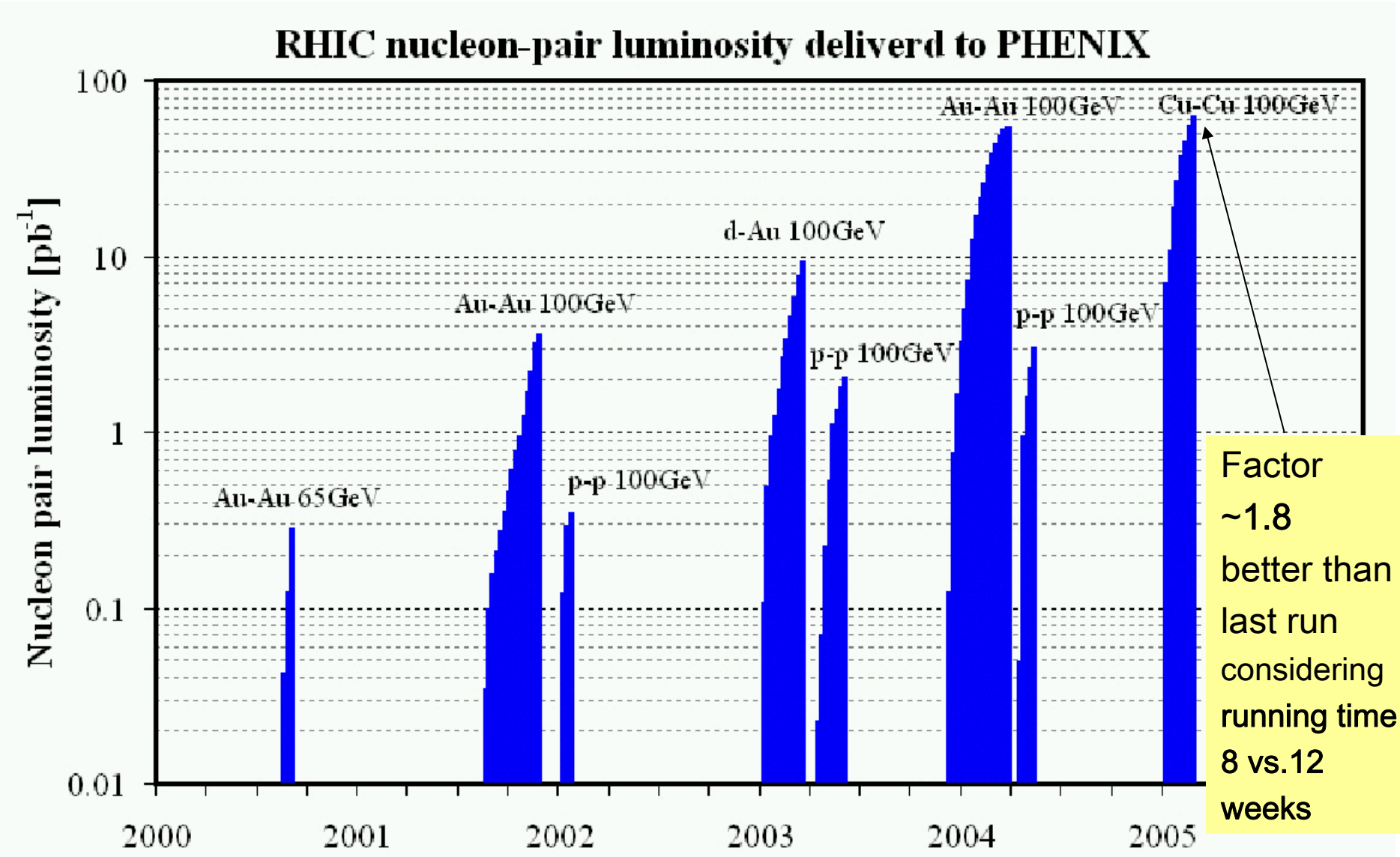
Discussed, planned, but ….

- STAR Magnet control from MCR
- ZDC's 'owned' bt CAD ***(→talk Tom)***
- collimation from sequencer
- store configurations (exp magnet polarities)
- **BLAM** ***(→talk Leif)***
- *Automatic orbit correction* ***(→talk Vadim)***

Run-5 integrated lumi (nb-1)

experiment	HE Run-5	HE Run-4	LE Run-5	LE Run-4
Phenix	**15.16**	1.37	**0.50**	0.022
Star	**14.99**	1.27	**0.46**	0.021
Brahms	**6.15**	0.56	**0.29**	0.012
Phobos	**5.67**	0.54	**0.24**	0.012

runs overview



Factor ~1.8 better than last run considering running time 8 vs.12 weeks

conclusion

All things considered, it was a pretty good run.

Thank you to the RHIC Operations Team for the great work done!